

CALIBRATION PROCEDURE

NI PXI-6653 and NI PXI-6652

This document contains information and step-by-step instructions for calibrating the 10 MHz oscillator frequency of the NI PXI-6653 and NI PXI-6652 timing and synchronization modules.

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What Is Calibration?

Calibration consists of two steps: verifying the accuracy of a device and correcting any discrepancy in the device accuracy and specified performance. *Verification* is measuring the device performance and comparing the results to the factory specifications. If the device is not operating within its specifications, use the second step of the calibration procedure to correct the error.

Why Should You Calibrate?

The accuracy of timing components can drift with time and temperature, which could cause the module to be less accurate than specified. Calibration ensures that the device still meets National Instruments specifications.

How Often Should You Calibrate?

The measurement requirements of the application determine how often you should calibrate the device to ensure its accuracy. National Instruments recommends that you calibrate the NI PXI-6653 and NI PXI-6652 yearly. You may want to shorten this interval based on the application demands.

Equipment and Other Test Requirements

This section describes the equipment, software, documentation, and test conditions required for calibrating the NI PXI-6653 and NI PXI-6652.

Test Equipment

Calibrating the NI PXI-6653 or NI PXI-6652 requires the following equipment:

- A highly stable 10 MHz clock source that is accurate to within 0.75 parts-per-billion (ppb) for the NI PXI-6653, or 150 ppb for the NI PXI-6652. NI recommends a rubidium frequency standard clock source.
- A cable for connecting a frequency source to the NI PXI-6653 or NI PXI-6652, most likely a BNC-to-SMB cable.
- An SMB-to-SMB cable for connecting two of the SMB terminals on the NI PXI-6653 or NI PXI-6652.

Software and Documentation

You need the following software and documentation to calibrate the NI PXI-6653 or NI PXI-6652:

- NI-Sync
- *NI-Sync User Manual*
- NI-VISA

Software

This calibration procedure requires NI-Sync and NI-VISA. NI-Sync and NI-VISA support a number of application development environments (ADEs) and programming languages, including LabVIEW, LabWindows[™]/CVI[™], and Microsoft Visual C++. When you install the drivers, you need to install support for only the ADE or programming language you are using. The illustrations in this manual show the LabVIEW code for implementing calibration steps using NI-Sync and NI-VISA.

Documentation

The *NI-Sync User Manual* contains detailed information about using the NI-Sync driver, including information about installing NI-Sync and creating applications that use the NI-Sync driver. These sources, along with this document, are your primary references for writing your calibration utility. You may also refer to the documentation for the programming language or application development environment you are using. For further information about the device you are calibrating, refer to the *NI PXI-665x User Manual*.

Test Conditions

Follow these guidelines to optimize connections and test conditions during the calibration procedure:

- Install the NI PXI-6653 or NI PXI-6652 in Slot 2 of your PXI chassis. The calibration procedure requires features of PXI that are accessible only in Slot 2.
- Maintain a temperature of approximately 25 °C.
- Keep relative humidity below 80 percent.
- Use shielded copper wire for all cable connections to the device.
- Allow a warm up time of at least 15 minutes for the NI PXI-6652 and three hours for the NI PXI-6653 to ensure the measurement circuitry is at a stable operating temperature.

Verifying the Oscillator Frequency of the NI PXI-6653 or NI PXI-6652

The following steps outline the procedure for measuring the 10 MHz oscillator frequency on the NI PXI-6653 and NI PXI-6652 and determining whether the device requires adjustment to meet the published specifications.

Connecting the Clock Source

The first step in determining the precise frequency of the onboard oscillator is to connect a highly accurate frequency source to the system. Connect the accurate 10 MHz source to the ClkIn connector on the NI PXI-6653 or NI PXI-6652. Using NI-Sync, program the NI PXI-6653 or NI PXI-6652 to route the ClkIn signal to PXI_Clk10In without using its 10 MHz PLL. Refer to Figure 1 and the *NI-Sync User Manual* for more information about how to program the NI PXI-6653 or NI PXI-6652 using NI-Sync.

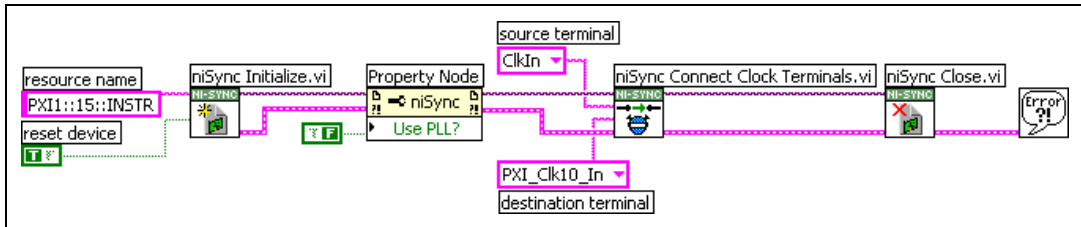


Figure 1. Replacing Clk10 From an External Frequency Source Using NI-Sync

Measuring the Frequency

Connect an SMB-to-SMB cable from ClkOut to PFI0 on the NI PXI-6653 or NI PXI-6652. Then, use NI-Sync to program the board to connect its onboard oscillator to ClkOut with the ClkOut high-gain setting enabled. Once the board has made this connection, use the NI-Sync Measure Frequency function to measure the frequency of the onboard oscillator.

For the NI PXI-6652, the frequency of the onboard oscillator should be measured to an accuracy of 200 ppb. To achieve this accuracy in the measurement, the Measure Frequency function should be programmed to measure for 0.5 seconds.

For the NI PXI-6653, the frequency of the onboard oscillator should be measured to an accuracy of 1 ppb. To achieve this accuracy in the measurement, the Measure Frequency function should be programmed to measure for 100 seconds.

Figure 2 shows a sample LabVIEW program that uses NI-Sync to measure the 10 MHz oscillator frequency for 0.5 seconds.

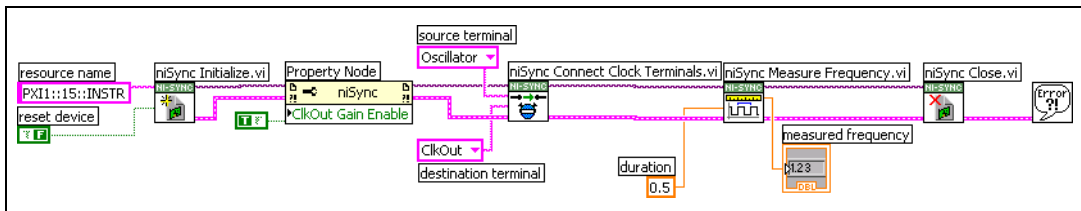


Figure 2. Measuring the 10 MHz Oscillator Frequency Using NI-Sync

Comparing the Measured Frequency to the Device Specifications

You need to compute the oscillator accuracy from the measured frequency obtained using the test described above. This accuracy can be compared to the specified accuracy in the appropriate section of the *NI PXI-665x User Manual*. For the NI PXI-6653, the oscillator specifications are listed in the *OCXO Characteristics* section of Appendix A, *Specifications*. For the NI PXI-6652, the oscillator specifications are listed in the *TCXO Characteristics* section of Appendix A, *Specifications*.

To determine the measured accuracy, subtract the nominal frequency (10 MHz) from the measured frequency and divide by the nominal frequency (10 MHz). Note that you must multiply the result by 1,000,000,000 to get units of parts per billion (ppb) and by 1,000,000 to get units of parts per million (ppm).

The device is considered to be in calibration if the accuracy (in units of ppb or ppm) is within the range specified in the *NI PXI-665x User Manual*.

Adjusting the Frequency of the 10 MHz Oscillator

If the accuracy of the 10 MHz oscillator is outside the specified range for the product, the device is out of calibration. A programmable voltage controls the oscillator frequency. By varying this voltage and precisely measuring the frequency, you can find a voltage that gives a frequency as close as possible to 10 MHz.

The oscillator control voltage is set by writing a value in the range 0x001C0000 to 0x001CFFFF to the register at offset 0x1C in the NI PXI-665x BAR1 memory space. You can do this most easily with VISA. The last 16 bits of the value determine the oscillator frequency setting.



Note Although the value stored in the register is 16 bits, the hardware uses only the upper 12 bits. The lower four bits are ignored.

It is usually best to start with a value of 0x001C8000, which is in the middle of the range, and increase or decrease the value from there.

You can measure the frequency each time the control voltage is changed, as described in the [Measuring the Frequency](#) section.



Note NI-Sync changes the oscillator control voltage back to the calibrated value if the board is reset.

Once the ideal value for the control voltage is determined, proceed to the next step, in which the new calibration value is written to the Calibration EEPROM. Figure 3 shows how to adjust the oscillator frequency using NI-VISA.

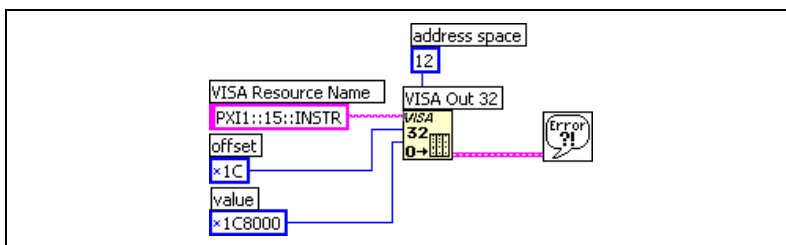


Figure 3. Adjusting the Frequency of the Clk10 Oscillator Using NI-VISA

Updating the Oscillator Frequency Calibration Value in the Calibration EEPROM

Once the ideal 16-bit value for the oscillator frequency setting has been determined, this value should be written to the Calibration EEPROM on the NI PXI-665x to complete the calibration. NI Sync provides a calibration API for writing a new calibration value to the Calibration EEPROM on the board. Note that the value obtained earlier must be scaled to a voltage before passing it into the **NI Sync Calibration VI**, which writes the oscillator frequency value to the EEPROM. The values from 0x0000 to 0xFFFF represent a range of voltages from 0.000 V to 4.095 V. Figure 4 shows the calculation necessary to convert the 16-bit value obtained in the steps above into the calibrated oscillator voltage that can be written to the board EEPROM using NI-Sync.

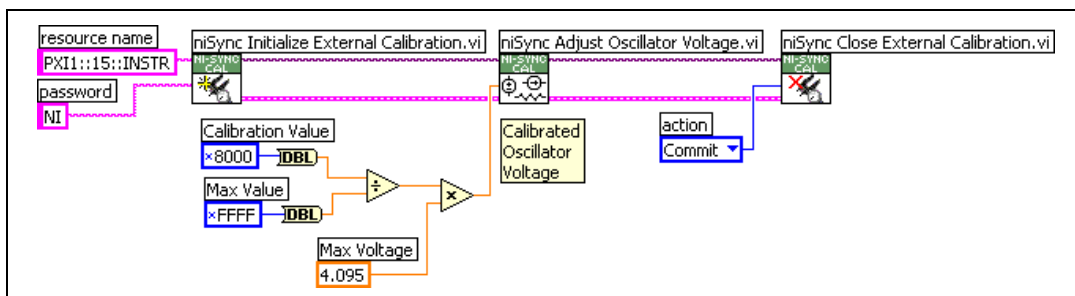


Figure 4. Writing the 10 MHz Oscillator Calibration Value Using NI-Sync



Note NI-Sync uses the new calibration value when the computer is rebooted.



Note *NI* is the default user password. If you have changed the calibration password, use your user-selected calibration password in place of *NI*.

